71-2

An Announcement of Recent Acquisitions. . .

HSL No. 71-2
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THIS ISSUE CONTAINS:

HS-008 380 - HS-008 415

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INTRODUCTION

Publications announced in *Highway Safety Literature* include the most recent additions to the collection of the NHTSA Scientific & Technical Information Service. Subject areas covered include all phases of highway, motor vehicle, and traffic safety, especially those encompassed by the National Traffic and Motor Vehicle Safety Act of 1966 and the Highway Safety Act of 1966.

Individual issues of *HSL* are numbered according to the year and the issue number within that year; thus, 71 designates the year and 1, 2, 3, etc. the individual issues. To aid the user in location citations by the HS-number, the cover bears the inclusive entry numbers for each issue.

Entries in *HSL* are arranged according to the revised NHTSA Subject Category List shown in the Table of Contents. The List is a two-level arrangement consisting of five major subject fields subdivided into 58 subject groups. Documents related directly to the National Highway Traffic Safety Administration (NHTSA) are announced in a separate section headed NHTSA DOCUMENTS and are numbered in five distinct series: NHTSA Accident Investigation Reports (HS-600 000 series), NHTSA Compliance Test Reports (HS-610 000 series), NHTSA Contractors Reports (HS-800 000 series), NHTSA Staff Speeches, Papers, etc. (HS-810 000 series), and NHTSA Imprints (HS-820 000 series). For NHTSA DOCUMENTS in series HS-600 000 and HS-610 000, individual full case reports are available for inspection at the National Highway Traffic Safety Administration; or for purchase from CFSTI (see page ii). Although announced together in a separate section, these documents are also assigned specific subject categories for machine retrieval.

A document which contains a number of separate articles is announced as a complete volume in the subject category most applicable to it as a whole. Entries for the individual articles appear in their most specific subject category.

SAMPLE ENTRIES

Subject Category Array

NHTSA Accession no..... HS-800 218 Fld. 5/21; 5/9

Title of document..... AN INVESTIGATION OF USED CAR SAFETY STANDARDS--SAFETY INDEX: FINAL REPORT. VOL. 6 - APPENDICES G-L

Personal author(s)..... by E. N. Wells; J. P. Fitzmaurice; C. E. Guilliams; S. R. Kalin; P. D. Williams

Corporate author..... Operations Research, Inc., Silver Spring, Md., 015000 ← For computer use only

Collation

Publication date..... 12 Sep 1969 150p
Contract FH-11-6921
Report no. ORI-TR-553-Vol-6; PB-190 523

Abstract..... Appendices G-L to this study of used car safety standards include: indenture model diagrams for classes I-IV motor trucks; degradation, wear, and failure data for motor truck classes I-IV; and safety index tables for classes I-IV motor trucks.

Search terms: Wear /Trucks; Failures /Trucks; Used cars; Inspection standards /Trucks; Inspection standards /Data

AVAILABILITY: NTIS

HS-004 497 Fld. 5/19

AUTO THEFT–THE PROBLEM AND THE CHALLENGE

by Thomas A. Williams, Sr.

Journal citation . . . Published in *FBI Law Enforcement Bulletin* v37 n12 p15-7 (Dec 1968)

Gives figures on the extent of the auto theft problem and comments on antitheft devices available now or in the planning stage.

Search terms: Theft, Theft protection, Stolen cars

TABLE OF CONTENTS

NOTE: ( ) Numbers in parentheses following certain subject groups indicate the Highway Safety Program Standards (No. 1, and up) and/or Federal Motor Vehicle Safety Standards (No. 101 and up) which may apply to these groups.

INTRODUCTION AND SAMPLE ENTRIES . . . . . **Inside Front Cover**

AVAILABILITY OF DOCUMENTS ii

NHTSA SUBJECT FIELDS AND GROUPS

1/0 ACCIDENTS 1
- /1 Emergency Services (11, 15-16)
- /2 Injuries
- /3 Investigation and Records (10, 14-15)
- /4 Locations (9, 14)

2/0 HIGHWAY SAFETY 1
- /1 Breakaway Structures
- /2 Communications
- /3 Debris Hazard Control and Cleanup (15-16)
- /4 Design and Construction (12, 14)
- /5 Lighting (14)
- /6 Maintenance (12)
- /7 Meteorological Conditions
- /8 Police Traffic Services (15)
- /9 Traffic Control (13-14)
- /10 Traffic Courts (7)
- /11 Traffic Records (10)

3/0 HUMAN FACTORS 1
- /1 Alcohol (8, 14)
- /2 Anthropomorphic Data
- /3 Cyclists
- /4 Driver Behavior
- /5 Driver Education (4, 14)
- /6 Driver Licensing (5, 10, 14)
- /7 Drugs Other Than Alcohol
- /8 Environmental Effects
- /9 Impaired Drivers
- /10 Passengers
- /11 Pedestrians (14-15)
- /12 Vision

4/0 OTHER SAFETY-RELATED AREAS 6
- /1 Codes and Laws (6)
- /2 Community Support (17)
- /3 Cost Effectiveness
- /4 Governmental Aspects
- /5 Information Technology
- /6 Insurance
- /7 Mathematical Sciences
- /8 Transportation Systems

5/0 VEHICLE SAFETY 7

* All Federal Motor Vehicle Safety Standards apply to passenger vehicles. An asterisk before a subject group indicates additional types of vehicles to which the indicated standards may apply.

- /1 Brake Systems (102, 105-6, 116)
- */2 Buses, School Buses, and Multipurpose Passenger Vehicles (102-4, 106-8, 111-3, 116, 205-6, 209, 211)
- */3 Cycles (3; 108, 112, 116, 205)
- /4 Design (14; 101-2, 105, 107, 201)
- /5 Door Systems (201, 206)
- /6 Fuel Systems (101, 301)
- /7 Glazing Materials (205)
- /8 Hood Latch Systems (113)
- /9 Inspection (1)
- /10 Lighting Systems (101, 105, 108, 112)
- /11 Maintenance and Repairs
- /12 Manufacturers, Distributors, and Dealers
- /13 Mirrors and Mountings (107, 111)
- /14 Occupant Protection (15; 201-4, 207-10)
- /15 Propulsion Systems
- /16 Registration (2, 10)
- /17 Safety Defect Control
- /18 Steering Control System (101, 107, 203-4)
- /19 Theft Protection (114-5)
- */20 Trucks and Trailers (102-4, 107-8, 112-3, 116, 205-6, 209)
- /21 Used Vehicles
- /22 Wheel Systems (109-10, 211)
- /23 Windshield-Related Systems (101, 103-4, 107, 205, 212)

NHTSA DOCUMENTS . . . . . –

EXECUTIVE SUMMARIES 9

NOTE: Material published in Highway Safety Literature (HSL) is intended for the information and assistance of the motor vehicle and highway safety community. While brands names, equipment model names and identification, and companies may be mentioned from time to time, this data is included as an information service. Inclusion of this information in the HSL should not, under any circumstances, be construed as an endorsement or an approval by the National Highway Traffic Safety Administration, Department of Transportation of any particular product, course, or equipment.

Harry A. Feinberg
Managing Editor

AVAILABILITY OF DOCUMENTS
AND
INSTRUCTIONS FOR ORDERING

Department of Transportation personnel may borrow copies of publications directly from the NHTSA. Outside the Washington, D.C. area, phone (202) 426-2768. In Washington, D.C. area, use government ID, phone 118-62768. Non-DOT personnel should contact their company or agency libraries for assistance.

Journals cited may be obtained through most research libraries.

Contractors' reports and other documents can usually be obtained as indicated under AVAILABILITY. However, there is no certainty that retention copies will be available for more than a limited period after a document is issued.

The more common distribution sources are identified by symbols which are explained below:

NTIS: National Technical Information Service (formerly Clearinghouse for Federal Scientific and Technical Information–CFSTI), Springfield, Va. 22151. *Order by accession number: HS, AD, or PB.* Prepayment is required by NTIS (CFSTI) coupon (GPO coupons are not acceptable), check, or money order (made payable to the NTIS). *HC* (Paper copy; full size original or reduced facsimile) $3.00 up; *MF* (microfiche approximately 4x6" negative sheet film; reader required) $0.95.

GPO: Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Give corporate author, title, personal author, and report number. Prepayment is required by GPO coupon (NTIS [CFSTI] coupons are not acceptable), check or money order (made payable to the Superintendent of Documents).

HRB: Highway Research Board, National Academy of Sciences, 2101 Constitution Ave., N. W., Washington, D C. 20418.

NHTSA: National Highway Traffic Safety Administration General Services Division, Washington, D.C. 20591 (Telephone (202) 426-0874).

SAE: Society of Automotive Engineers, Dept. HSL, 2 Pennsylvania Plaza, New York, N.Y. 10001. Order by SAE report number. Prices given are list; discounts are available to members and sometimes to libraries and U.S. Government Agencies. Prepayment is required; orders without payment are subject to a $1 handling charge.

IMPORTANT

WHEN REQUESTING a document, to be absolutely sure you receive what you order, give the accession number (HS, PB, AD number) or report number (in cases such as an SAE document), title of report, and the personal or corporate author (whichever is cited). When requesting an HS-numbered document from NTIS (CFSTI), add DOT/ to the prefix HS-; example HS-800 000 should be ordered as DOT/HS-800 000.

SPECIAL NOTICE

NEW PRICES FOR DOCUMENTS AVAILABLE FROM NTIS

On January 1, 1971, the National Technical Information Service (NTIS) increased the prices for documents in certain categories. These increases were made necessary by increased costs. Prices are now as follows:

PAPER COPY

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Documents announced prior to January 1, 1969, have a service charge of $3.00 added to the announced price.

MICROFICHE

Microfiche reproduction of documents on a demand basis are priced at 95 cents per document.

Documents available on Standing Order through NTIS Selective Dissemination of

HS-008 380 Fld. 1/1

COMMUNITY ACTION ON EMERGENCY MEDICAL SERVICE

Anonymous

Published in *Journal of the Medical Association of the State of Alabama*, v37 n9 p1003, 1106, 1109-11 (Mar 1968)

An estimated 20,000 victims of automobiles and other accidents die needlessly each year because of inadequate emergency medical services. Fatalities and injuries increase annually. This report offers guidelines to aid formation of community action programs in the following areas: first aid; communications; transportation; and emergency facilities.

Search terms: Emergency medical services /Community support; First aid; Highway communications / Emergencies; Ambulances

1/3 Investigation and Records

HS-008 381 Fld. 1/3

NON-INVOLVED VEHICLE ACCIDENT ELEMENTS

by Paul C. Box

Published in *Public Safety Systems* v35 n5 p15-7 (Sep-Oct 1970)

In preparing collision diagrams, the role of vehicles which were not physically struck but caused other vehicles to crash should be considered. Such vehicles often have a role in turning, intersection, and rear end collisions. Pedestrians also may cause an accident without being themselves struck, when a driver stops to yield the right of way and then is struck from behind. A symbol is suggested for use on collision diagrams to indicate such a vehicle or pedestrian.

Search terms: Accident causes / Accident reconstruction; Pedestrian accidents /Accident causes; Accident reconstruction: Rear end collisions /Accident causes; Turning /

2/0 HIGHWAY SAFETY

2/2 Communications

HS-008 382 Fld. 2/2; 5/2

THE CASE FOR TWO WAY BUS RADIOS

Anonymous

Published in *Highway User* p20-1 (Nov 1967)

In cities where buses are equipped with radio, the results have been better service and greater passenger and driver safety. Radio has proved useful in handling transportation emergencies and is helpful in crime prevention.

Search terms: Radio communication /Buses; Emergencies /Radio communication; Crime /Radio communication

2/9 Traffic Control

HS-008 383 Fld. 2/9

SYMBOLS, DIMENSIONS AND LAYOUT FOR SAFETY SIGNS. 1ST. ED.

International Organization for Standardization, Geneva, Switzerland,I44100

Mar 1967 8p

Report no. ISO-R-557-1967-E

This recommendation applies to the dimensions of safety signs in geometric forms, the symbolic images to be placed on the signs, and the layout of the signs. These signs are applicable to highway safety for such situations as transport of hazardous materials, first aid services, and possibility of falling stones.

Search terms: Safety sign standardization /International aspects; Emergencies /Highway signs; Hazardous materials /Highway signs

3/0 HUMAN FACTORS

3/4 Driver Behavior

HS-008 384 Fld. 3/4

Published in *Trial Magazine* v4 n4 p52-3 (Jun-Jul 1968)

From a report of the Department of Health, Education and Welfare's Advisory Committee on Traffic Safety, chaired by Daniel P. Moynihan.

In this excerpt, formal "safe driving" advice is contrasted with automotive advertising directed to young consumers wherein products are associated with forms of violent or aggressive behavior. Suggests that research efforts be directed toward the general subject of the epidemiology of violence in human society.

Search terms: Driver behavior; Psychological factors /Accident causes; Accident proneness /Advertising; Advertising /Safety propaganda

HS-008 385 Fld. 3/4; 4/7

MATHEMATICAL MODELS AND SIMULATION OF AUTOMOBILE DRIVING. PROCEEDINGS ON A CONFERENCE HELD AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY, SEPTEMBER 28-29, 1967

National Center for Urban and Industrial Health, Cincinnati, Ohio. Injury Control Program, N13800

Sep 1967 221p 121 refs

These proceedings are the written statements of the principal investigators of the several PHS grants plus others from universities, industry, and government concerned with mathematical models of the driver-vehicle-environment. The specific purpose of the conference was to appraise the results gained to date, the major problems, and how research efforts should be refocused.

Search terms: Mathematical models /Driving simulation; Information systems /United State Government; Driving simulators; Driving simulation /Conferences; Driving simulation research /Federal aid

AVAILABILITY: (Includes HS-008 386 to HS-008 407)

HS-008 386 Fld. 3/4

DRIVING MODELING AND DRIVING SIMULATION

by Joseph B. Bidwell

General Motors Research Labs., Warren, Mich., G10800

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p5-11 (28-29 Sep 1967)

Sep 1967 7p 11 refs

On the basis of experience to date, the development of high fidelity driving simulation equipment is not necessary for most of the experimental work required. Experiments can be done in real cars in controlled driving environments including simulated accident situations with far fewer problems than would be involved in simulation. Physiological measurements are somewhat more difficult.

Search terms: Driving simulation; Driver performance /Mathematical models; Instrumented vehicles

AVAILABILITY: *In* HS-008 385

HS-008 387 Fld. 3/4; 5/18

SOME REAL-WORLD RESULTS ON CAR STEERING IN RELATION TO AUTOMOBILE-DRIVER MODELS AND LABORATORY SIMULATION

by E. R. F. W. Crossman

California Univ., Berkeley. Operations Research Center, C17100

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at Mass. Inst. of Tech.*, p12-17 (28-29 Sep 1967)

Sep 1967 6p
Grant PHS-AC-00260

Effort to date on the research into vehicle/driver steering dynamics has been largely performed by using an instrumented experimental vehicle in field tests. Beginnings are being made to obtain satisfactory data which can be used to test what may perhaps be termed the "conventional" closed-loop model of the vehicle/driver system. This would include a continuous quasi-linear human operator with adaptive gain and filter characteristics in tandem with a linear vehicle.

Search terms: Instrumented vehicles /Steering; Driving simulation / Driver vehicle interface; Driving simulation /Driver road interface; Driving simulation /Cybernetics

AVAILABILITY: *In* HS-008 385

HS-008 388 Fld. 3/4

DRIVING SIMULATION AND MODELING

by Benjamin C. Duggar

Bio-Dynamics, Inc., Cambridge, Mass., B13200

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p18-20 (28-29 Sep 1967)

Sep 1967 3p

Activities in driving simulation are briefly described. A driving simulator has been modified to permit the simulation of skids and an experiment designed to determine transfer of training to an automobile and skid pan situation. Training criteria for front wheel lock, rear wheel lock, four wheel lock, curve spin out, and retaining control while braking have been devised for both simulator and car. Computer programs have been prepared to take taped data and derive steering wheel reversals.

Search terms: Driving simulators / Skidding; Driving simulators /Wheel locking; Driving simulators /Steering; Steering /Computer programs

AVAILABILITY: *In* HS-008 385

HS-008 389 Fld. 3/4; 5/18

THE DAVIDSON LABORATORY AUTOMOTIVE STABILITY INVESTIGATION

by I. Robert Erlich

Stevens Inst. of Tech., Hoboken, N. J. Davidson Lab., S44400

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p21-4 (28-29 Sep 1967)

Sep 1967 4p
Grant PHS-AC-00300

A driving simulator is described, and its use for measuring the driver automotive interface is outlined. Preliminary findings in a secondary task study indicate that an increased performance demand on one of the tasks will show up as decreased performance on the other. Presently being recorded are the vehicle yaw rate, the steering wheel deflections, galvanic skin response of the subject, disturbance signal and a signal which is a time integral for one minute periods of the driver error signal which is used as a measure for "time off target." Vehicle yaw rate appears to be the best measure of driver error. Components of the simulator consist of the body of a two-door sedan, a screen and movie projector, an analog computer, and a set of amplifier driving strip chart recorders.

Search terms: Driving simulators / Analog computers; Instrumented vehicles; Driving simulators /Steering; Driving simulators /Driving tasks; Driving simulation /Galvanic skin response; Driving simulation / Driver performance; Driver performance /Yaw

AVAILABILITY: *In* HS-008 385

HS-008 390 Fld. 3/4; 5/18

TRANSPORTATION RESEARCH IN HIGHWAY AUTOMATION

by Robert E. Fenton

Ohio State Univ., Columbus. Dept. of Electrical Engineering, O06600

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p25-36 (28-29 Sep 1967)

Sep 1967 12p 24 refs

Investigations conducted on a simulator and under corresponding real world conditions lead to the following conclusions: The simulator testing can be used to obtain average measures of a subject's performance which approximate the corresponding real world values, and models of a subject's behavior obtained from the simulator probably are not valid under corresponding real world conditions. Simulated and real world car following studies using various types of controls such as stick controls are reported. Application to automatically controlled vehicles is the intent of these studies. An improved simulator designed to simulate the steering task is described.

Search terms: Automatic highways; Driving simulators /Driving performance; Car following /Stick control; Car following /Steering; Driving simulators /Steering

AVAILABILITY: *In* HS-008 385

HS-008 391 Fld. 3/4; 4/7

MATHEMATICAL MODELS AND SIMULATION OF DRIVING

by W. R. Ferrell; T. B. Sheridan

Massachusetts Inst. of Tech., Cambridge, M15000

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p37-9 (28-29 Sep 1967)

Sep 1967 3p
Grant PHS-AC-00206

Drastic simplification of the driving situation has been necessary to make it tractable for modeling and measurement. The preview models are of two kinds—tracking and information transmission. Several models are described. A simulator which can be automatically controlled is described. That vestibular feedback is important is noted.

Search terms: Driving simulation / Mathematical models; Steering / Driving simulation; Highway communication /Driving simulation; Vestibular apparatus /Driving simulators; Instrumented vehicles /Automatic control

AVAILABILITY: *In* HS-008 385

HS-008 392 Fld. 3/4; 4/7

SOME INDICATORS FOR AND AGAINST SIMULATION RESEARCH

by Bernard H. Fox

National Center for Chronic Disease Control, Arlington, Va., N12600

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p40-4 (28-29 Sep 1967)

Sep 1967 5p

Simulation, especially driving simulation, as a method of research is discussed. It is suggested that it might be well to get external measures of disturbances and of accident associated circumstances. Given such measures one would then be in a position to specify the probability that in the first place, simulation research will bring about a useful product, and secondly, whether simulation should be the research method of choice. Criteria for using simulation follow: safety offered by simulation; cost saving; accuracy. Mathematical model researchers should be extremely careful about the assumptions they make in regard to human performance, since the literature does not, even at this late stage, give good indication of results of certain degradations or certain long term conditions where step changes may take place.

Search terms: Driving simulation / Accident research; Driving simulation /Safety; Driving simulation / Costs; Driving simulation /Reliability; Driver performance /Mathematical models

AVAILABILITY: *In* HS-008 385

HS-008 393 Fld. 3/4; 5/18

SUMMARY OF RESEARCH PROGRAM

by Ed Heitzman

Princeton Univ., N. J. Dept of Aerospace and Mechanical Sciences, P33600

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p45-7 (28-29 Sep 1967)

Sep 1967 3p
Grant PHS-Grant-00298

Princeton's program on automobile dynamics is a theoretical-experimental study of the car-driver system. It is characterized by development of mathematical models of the car, driver, and disturbance functions from data obtained in road tests, with experimental validation of the models in further road tests. A variable stability car is to be used in development and verification of the system models.

Search terms: Driver simulation / Mathematical models; Mathematical models /Validation

AVAILABILITY: *In* HS-008 385

HS-008 394 Fld. 3/4; 4/7

RECENT RESEARCH

by Paul M. Hurst

Institute for Research, State College, Pa., 129400

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p48-52 (28-29 Sep 1967)

Sep 1967 5p 13 refs

This paper suggests that greater emphasis might profitably be placed on naturalistic findings when developing models to predict real world behavior. Methodology in developing a model for decision making situations such as headway control and lane changing is briefly outlined.

Search terms: Driving simulation / Mathematical models; Driving simulation /Headway; Driving simulation /Lane changing

AVAILABILITY: *In* HS-008 385

HS-008 395 Fld. 3/4; 4/7

A DISCUSSION OF DRIVER MODELING

by Edwin A. Kidd

Cornell Aeronautical Lab., Inc., Buffalo, N. Y., C67200

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p53-7 (28-29 Sep 1967)

Sep 1967 5p

A combined theoretical and experimental approach has been taken to investigate the dynamics of movement of traffic through urban intersections. The formulated model focuses upon the driver's perceptual, decision making, and response processes as the crucial factors. It also takes into account vehicle characteristics and environmental conditions. Experimental research has included specific laboratory and full scale experiments to provide perceptual and decision making data for basic inputs to the model and real traffic observational studies for validation of model output.

Search terms: Urban intersections /Driver performance; Mathematical models /Validation; Driver

3/4 Driver Behavior (Cont'd)

HS-008 395 (Cont'd)

vehicle interface; Driver performance /Environmental factors; Driver simulation /Perception; Driver performance /Mathematical models; Intersections /Driver simulation

AVAILABILITY: *In* HS-008 385

HS-008 396 Fld. 3/4

AUTOMOBILE ACCIDENTS AND A CONTROL ENGINEERING MODEL OF DRIVER SKILL

by Ezra S. Krendel

Pennsylvania Univ., Philadelphia, P12000

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p58-62 (28-29 Sep 1967)

Sep 1967 5p

A major shortcoming of accident research is that the definition of the accident is conventionally in terms of its results only; i.e., a performance measure which is so insensitive that it is a binary function whose threshold defines disaster. A more sensitive model applicable to automobile driving is described. This model emphasizes the perceptual aspect of the development of motor skill. Within the frame work of this model, potential sources of accidents can be examined. It is a fundamental assumption that the net result of lapses in skilled system performance is a potential accident. Study and evaluation of such lapses will provide a structure for accident reporting and more nearly people-proof the driver/vehicle/roadway combinations.

Search terms: Accident investigation; Driving simulation /Perception; Simulation models /Perception; Simulation models /Accident risks; Simulation models /Driver performance; Simulation models /Attention lapses

HS-008 397 Fld. 3/4

THE USE OF DRIVING SIMULATORS AT THE USPHS DRIVING RESEARCH LABORATORY

by R. K. McKelvey

Public Health Service, Providence, R. I. Driving Research Lab., P38800

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p63-84 (28-29 Sep 1967)

Sep 1967 3p

The USPH Driving Research Laboratory is providing three basic kinds of facilities: a general purpose laboratory for driving task research; open loop driving simulators; and a field test facility. Problems in validating simulators are raised. An evaluation of simulator sickness is presented. Vigilance, visibility, distraction and perception of signals and traffic hazards are discussed. Driving simulators which not only teach procedures but also improve psychomotor skill are being introduced. Visual, motion, vibratory, and auditory signals are correlated to correspond more exactly with the real life characteristics of the vehicle in situ. An outline for acquiring and improving driver skills is included.

Search terms: Driving simulation / Test facilities; Driving task research; Driving simulators /Validation; Simulator sickness; Driving simulation / Perception; Driver education /Driving simulators; Driver improvement /Driving simulators; Driver skills /Driving simulators; Vigilance /Driving simulation; Visibility /Driving simulation; Accident risks /Driving simulation; Instrumented vehicles

AVAILABILITY: *In* HS-008 385

HS-008 398 Fld. 3/4

CURRENT AND PROJECTED RESEARCH

by Gordon H. Robinson

Wisconsin Univ., Madison. Industrial Engineering Div., W24000

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at*

Sep 1967 5p
Grant PHS-UI-00323

Experimental efforts are being attempted to describe visual search patterns necessary to or commonly found in driving and to measure the effects on visual search of individual differences, experience, task complexity, and stress. Four levels, or degrees, of simulation will be employed: observations of the driver who is unaware his performance is being measured; test vehicles on the road; laboratory simulation using a hybrid computer and oscilloscopic display; and general laboratory experiments using human control and communications tasks.

Search terms: Driving simulation / Perception; Driving simulation / Accident risk; Driver performance / Road tests; Instrumented vehicles / Driver performance; Driving simulators /Driver performance; Highway communication /Driver performance

AVAILABILITY: *In* HS-008 385

HS-008 399 Fld. 3/4

CURRENT RESEARCH WITHIN THE SYSTEMS RESEARCH GROUP OF THE DEPARTMENT OF INDUSTRIAL ENGINEERING

by T. H. Rockwell

Ohio State Univ., Columbus, O05400

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p90-7 (28-29 Sep 1967)

Sep 1967 8p
Grant PHS-AC-00254

The Systems Research Group has focused its research over the past six years on studying normative driving skill and judgment on the road using experimental test vehicles and highly practiced subjects who usually serve as their own controls. The studies range from rear end signal systems design, fatigue studies, effect of carboxyhemoglobin on performance and the factors influencing information acquisition. Information is being collected on driver search and scan patterns. Efforts are being directed to more realistic models of car following. Attempts are being made to combine

decision theory as a basis for explaining field developed relative velocity detection data. Also, a computer simulation of the car following tasks has been developed.

Search terms: Instrumented vehicles /Driving skills; Instrumented vehicles /Driver performance; Simulation models /Car following

AVAILABILITY: *In* HS-008 385

HS-008 400 Fld. 3/4

ON THE INTEGRATION OF FULL SCALE TESTS INTO DRIVER MODELING

by Melvin H. Rudov

Cornell Aeronautical Lab., Inc., Buffalo, N. Y., C67200

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p98-100 (28-29 Sep 1967)

Sep 1967 4p

Human perception of a collision course at an intersection is reported. An instrumented automobile was used on an unused airport runway. The findings were these: the speed of the other vehicle had little effect on any of the measures; the subjects correctly identified a higher percentage of the collision courses as the test start distances decreased; the time to make a decision was almost a constant proportion of the total distance to the intersection; the evasive action used was appropriate to the situation. This type of study can be placed into a mathematical model of decision making. Because of the types of errors which can very easily result from assumptions made about driver performance, it is felt that all future driver models must be supported by simulator or full scale tests.

Search terms: Instrumented vehicles /Driver performance; Intersection collisions /Field tests; Decision making /Intersection collisions

AVAILABILITY: *In* HS-008 385

HS-008 401 Fld. 3/4

SUMMARY OF PRESENT AND PLANNED RESEARCH ACTIVITIES

by L. Segel

Michigan Univ., Ann Arbor. Highway Safety Research Information Center, M40200

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p101-5 (28-29 Sep 1967)

Sep 1967 5p

Research objectives and requirements to achieve these objectives in extending knowledge of the man vehicle are discussed. Usefulness of mathematical models in such research is considered.

Search terms: Mathematical models /Driver vehicle interface; Research /Driver vehicle interface

AVAILABILITY: *In* HS-008 385

HS-008 402 Fld. 3/4; 4/7

AN INFORMATION PROCESSING APPROACH TO THE AUTOMOBILE DRIVING ACTIVITY

by John W. Senders

Brandeis Univ., Waltham, Mass., B24600; Massachusetts Inst. of Tech., Chambridge, M15000

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p106-7 (28-29 Sep 1967)

Sep 1967 2p
Grant PHS-AC-00202

A mathematical modeling of the information flow process together with some predictions about the ways in which information is intermittently taken in by the observer from the terrain which is being continuously traversed is briefly described. The experiment consisted of setting the automobile in motion at a constant speed, occluding the driver's view of the road with a helmet mounted visor, and recording the intervals of occlusion between the driver's voluntary raisings of the visor for a look of fixed duration. The record of the occlusion duration is then a running behavioral index of the attentional demand placed on the driver by the total situation. This approach allows one to use a single measurement system for making quantitive estimates of the demand placed upon a driver by a number of different aspects of the driving situation.

Search terms: Mathematical models /Driving simulation; Driver performance /Cybernetics; Instrumented vehicles /Driver performance

AVAILABILITY: *In* HS-008 385

HS-008 403 Fld. 3/4; 4/7

A VIEW OF THE UTILITY OF MATHEMATICAL MODELING AND SIMULATION OF DRIVING

by B. W. Stephens

Bureau of Public Roads, Washington, D. C., B33600

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p108-16 (28-29 Sep 1967)

Sep 1967 8p 12 refs

Simulation with and without the human operator can augment the understanding of how the driver drives and how the driving system might be improved. Likewise it provides a set of laboratory tools for analyzing driving type activities. Research into steering response is described briefly, as is validation of the mathematical model.

Search terms: Driving simulation; Driving tasks; Mathematical models /Validation; Steering /Mathematical models

AVAILABILITY: *In* HS-008 385

HS-008 404 Fld. 3/4; 4/7

EXPERIMENTAL VALIDATION OF DYNAMIC MODELS

by John Versace

Ford Motor Co., Dearborn, Mich. Automotive Safety Research Office, F19200

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p117-29 (28-29 Sep 1967)

28-29 Sep 1967 13p 10 refs

Discusses structural and functional models and their validation.

Search terms: Models /Validation

AVAILABILITY: *In* HS-008 385

HS-008 405 Fld. 3/4

DYNAMIC MODELS FOR THE STUDY OF DRIVER/VEHICLE CONTROL LEADING TO A REDUCTION OF THE HAZARD IN DRIVING

by David H. Weir

Systems Technology, Inc., Hawthorne, Calif., S63600

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p130-33 (28-29 Sep 1967)

Sep 1967 4p 4refs

Discusses applications of models in a multiple loop feedback system which satisfies the guidance and control needs of the driver-plus-vehicle in its interaction with surroundings.

Search terms: Models /Driver vehicle interface; Models /Driver road interface; Driver performance / Cybernetics

AVAILABILITY: *In* HS-008 385

HS-008 406 Fld. 3/4

DYNAMIC MODELING OF THE DRIVER

by Walter W. Wierwille

Cornell Aeronautical Lab., Inc., Buffalo, N. Y., C67200

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p134-43 (28-29 Sep 1967)

Sep 1967 10p 17 refs

Dynamic modeling of the driver has been shown feasible in recent studies. It holds promise for obtaining quantitative information regarding the way in which the human being controls an automobile. Among the driving tasks that can be investigated by dynamic modeling are lane keeping, disturbance recovery, turning maneuvers, and obstacle avoidance or lane changing. These tasks can be modeled for various settings of independent variables, including road condition, vehicle condition, and driver physiological and mental condition. The quantitative results of dynamic modeling can be used to determine the degree of driver-vehicle system stability, and to determine those aspects of the driving task where the vehicle or driver proficiency needs improvement.

Search terms: Driving simulation / Driving tasks; Driving simulation / Driver vehicle interface; Driving simulation /Driver road interface; Driving simulation /Driver improvement; Motor vehicle safety

AVAILABILITY: *In* HS-008 385

HS-008 407 Fld. 3/4

THE DRIVING SIMULATOR—A RESEARCH TOOL

by C. K. Wojcik; Slade F. Hulbert

California Univ., Los Angeles. Inst. of Transportation and Traffic Engineering, C21000

Published in *Mathematical Models and Simulation of Automobile Driving. Proceedings of a Conference held at MIT*, p144-54 (28-29 Sep 1967)

Sep 1967 14p 9 refs

A driving simulator is described to include discussions of visual display, inertial forces, instrumentation, and the vehicle.

Search terms: Driving simulators / Force; Driving simulation /Instrumented vehicles; Driving simulators /Communication systems

AVAILABILITY: *In* HS-008 385

3/5 Driver Education

HS-008 408 Fld. 3/5

DRIVER IMPROVEMENT SCHOOLS: A GUIDE FOR THEIR OPERATION. 1963

by Harry D. Fletcher

American Automobile Assoc., Washington, D. C., Traffic Engineering and Safety Dept., A29400

1963 30p 42 refs

Guidelines for organizing and administering a driver improvement school are outlined. Lesson plans for a four session course are included.

Search terms: Driver improvement schools /Curricula; Driver improvement schools /Administration

AVAILABILITY: Corporate author

HS-008 409 Fld. 3/5; 3/4

"TALK-OUT" FOR TEENS

by Barbara S. Marx; Lawrence E. Schlesinger

Published in *Traffic Safety* v65 n6 p14-6, 36-7 (Jun 1965)

Source document: *A Group Discussion Program for Changing Attitudes of Younger Traffic Violators.* George Washington University, Washington, D. C., 1964. 180 p. HS-001 459.

A manual for group discussions on driving problems geared to teenagers is described. The aim of the program is to improve driving attitudes of teen age traffic violators. The manual contains outlines for 12 discussion sessions. It is not expected that the leader would use all of these sessions with one group. For the convenience of the instructor, each session is presented in a series of easy to follow steps. Preliminary information gained from program evaluation indicates that insight into attitudes that effect driving is being developed.

Search terms: Driver improvement schools /Driver attitudes; Adolescent drivers /Driver improvement schools; Adolescent drivers /Discussion groups

4/0 OTHER SAFETY-RELATED AREAS

4/6 Insurance

HS-008 410 Fld. 4/6

FACING FACTS ON AUTO INSURANCE REFORM

by Richard E. Stewart

Published in *Forum* v6 n1 p42-50 (Oct 1970)

The present tort liability system for compensating the victims of automobile accidents is criticized. Its failures are concluded to be: slow payment; one of every four victims unpaid; overpayment of small claims; underpayment of large claims; wasteful costs of insurance; duplication of other insurance; inability to deter unsafe driving.

It is proposed that fundamental changes in this legal system are needed and that negligence should be eliminated as the basis for compensation, with insurance benefits payable to each party regardless of fault; and that insurance on this basis should be compulsory.

Search terms: No fault insurance plan; Torts /Liability; Compensation /Accident costs; Negligence / Liability; Insurance industry /Legal factors; Liability insurance; Insurance rates; Insurance claims; Careless driving /Liability; Negligence / Compensation

5/0 VEHICLE SAFETY

5/9 Inspection

HS-008 411 Fld. 5/9; 5/20

SELECTED SAFETY ROAD CHECKS, MOTOR CARRIERS OF PROPERTY. 1969.

Bureau of Motor Carrier Safety, Washington, D. C., B32400

1970 13p

Roadside safety inspections of 46,731 trucks, tractors, trailers, and semitrailers during the calendar year 1969 found 10,781 of these vehicles, or 23.1%, unsafe for continued operation on the highway. These vehicles were ordered out of service at the point of inspection until specified minimum repairs had been completed. Since these vehicles were drawn from passing traffic on a selective basis, they are not a representative sample. There was an average of 146.8 defects for each 100 vehicles inspected. Defects are broken down by type of vehicle, kind of carrier, and defect categories.

Search terms: Motor vehicle inspection /Trucks; Motor vehicle inspection /Tractors; Motor vehicle inspection /Trailers; Motor vehicle inspection /Semitrailers; Defective vehicles /Trucks; Defective vehicles / Tractors; Defective vehicles /Trailers; Defective vehicles /Semitrailers; Sampling /Motor vehicle inspection; Sampling /Defective vehicles; Motor carriers /Defective vehicles; Motor carriers /Motor vehicle inspection

HS-008 412 Fld. 5/9; 5/20

SELECTED SAFETY ROAD CHECKS, MOTOR CARRIERS OF PROPERTY, YEAR 1968

Bureau of Motor Carrier Safety, Washington, D. C., B32400

1969 20p

During 1968 roadside inspections of 53,067 trucks, tractors, and trailers were made. Of this number 11,835 or 22.3% were judged mechanically unsafe for continued operation and were ordered out of service at the check point until essential repairs had been made. These vehicles were selected from passing traffic because they did not appear to be well maintained and thus do not comprise a representative sample. An average of 153.3 defects per 100 vehicles inspected was found. Defects are broken down by type of vehicle, kind of carrier, and defect categories.

Search terms: Motor vehicle inspection /Trucks; Motor vehicle inspection /Tractors; Motor vehicle inspection /Trailers; Defective vehicles / Trucks; Defective vehicles /Tractors; Defective vehicles /Trailers; Sampling /Motor vehicle inspection; Sampling /Defective vehicles; Motor carriers /Defective vehicles; Motor carriers /Motor vehicle inspection

5/10 Lighting Systems

HS-008 413 Fld. 5/10; 2/4

HEADLIGHT GLARE AND MEDIAN WIDTH–THREE EXPLORATORY STUDIES

by Lawrence D. Powers, David Solomon

Published in *Public Roads* v33 n7 p125-142 (Apr 1965)

Study results of headlight glare showed that the effects of glare decreased with increasing lateral separation of the glare car and the opposing vehicle. At any given lateral separation, the effects of the glare were present even when the glare car was at a considerable distance from the observer (3,000 feet or more); the rate of change of the effect with distance was small for a large part of this distance. These results are derived from three studies in the first of which the glare car and target were stationary. In study 2, both target and test subject were stationary and the glare car moved toward test subject. In study 3, a self luminous target was used and both target and test subject were stationary as the glare car moved toward the subject; he continuously adjusted the brightness of the target and attempted to keep it barely detectable. Some limited measurements of discomfort caused by glare were made but abandoned because of variability of results.

Search terms: Headlamp glare / Lateral vehicle separation; Glare tolerance; Headlamp glare /Field tests; Headlamp glare /Median barrier design; Headlamp glare / Visibility

HS-008 414 Fld. 5/10; 2/4; 3/12

AN INVESTIGATION OF HEADLIGHT GLARE AS RELATED TO LATERAL SEPARATION OF VEHICLES

by L. A. Webster; F. R. Yeatman

Illinois Univ., Urbana. Engineering Experiment Station, I6200

1968 125p 291 refs
Report no. BULL-496

The headlight glare project was initiated to study the tolerable levels of headlight glare as related to median performance. The current knowledge on headlight glare is reviewed. Field testing included disability glare, which affects seeing distance, and discomfort glare, a psychological phenomenon. Conclusions as to the optimum lateral separation of vehicles for providing seeing distances are given.

Search terms: Night driving /Headlamp glare; Headlamp glare /Lateral vehicle separation; Median barriers / Visibility; Vision tests /Glare; Headlamp glare /Field tests; Headlamp glare /Glare tolerance; Median barrier design /Headlamp glare

AVAILABILITY: Corporate author

5/17 Safety Defect Control

HS-008 415 Fld. 5/17

DYNAMIC QUALITY CONTROL

by H. L. Ohl

1968 36p

Presented at The Third Annual Management Workshop-Seminar, Automotive Division of the American Society for Quality Control, Dearborn, Michigan, Nov. 13, 1968.

The quality control program used in the manufacture of Opel cars is discussed. Aspects of the program include the rating of suppliers and inspection of the parts supplied by them, a defect reporting system, data processing of quality control and inspection information.

Search terms: Quality control / European vehicles; Defective vehicles /European vehicles; Defective vehicles /Quality control; Motor vehicle inspection /Quality control; Data processing /Quality control; Data processing /Motor vehicle inspection; Automotive industry / Quality control

executive summary

A SYNOPSIS OF A RECENTLY RELEASED NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION RESEARCH REPORT

BASIC RESEARCH IN AUTOMOBILE CRASHWORTHINESS
SUMMARY REPORT

The purpose of the over-all study "Basic Research in Automobile Crashworthiness" was to determine the feasibility of designing a vehicle/frame structure that would provide optimum deceleration rates for the full periphery of a vehicle under impaction with a solid object.

Contract No. FH-11-6918
Cornell Aeronautical Laboratory,
Incorporated
4455 Genesee Street
Buffalo, New York 14221
DOT/HS-800 315

Total Project Award Amount: $486,726.00
Date Report Rec'd: 8/3/70
Release Date: 12/9/70

This synopsis is the final in a series of seven reports resulting from the same basic research. The summary covers the first five reports in the over-all study. Each of the seven reports completed and their sub-titles appear as follows:

1. "Basic Research in Automobile Crashworthiness – Testing and Evaluation of Forward Structure Modification Concept", CAL Report No. YB-2684-V-1; (DOT/HS-800 203 PB-189 274 Released 2/3/70)

2. "Basic Research in Automobile Crashworthiness – Testing and Evaluation of Engine Deflection Concept", CAL Report No. YB-2684-V-2; (DOT/HS-800 310 Released 11/4/70)

3. "Basic Research in Automobile Crashworthiness – Testing and Evaluation of Modifications for Side Impacts", CAL Report No. YB-2684-V-3 (Summary Pending)

4. "Basic Research in Automobile Crashworthiness – Testing and Evaluation of Rear Engine Concept", CAL Report No. YB-2684-V-4; (DOT/HS-800 270 PB-194 201 Released 9/3/70)

5. "Basic Research in Automobile Crashworthiness – Analytical Studies", CAL Report No. YB-2684-V-5; (DOT/HS-800 313)

6. "Basic Research in Automobile Crashworthiness – Summary Report", CAL Report No. YB-2684-V-6; (DOT/HS-800 315)

7. "An Experimental Evaluation of the 1969 Volkswagen 1500 Restraint System and Front Assembly", CAL Report No. YB-2684-V-100. (DOT/HS-800 204 PB-193 718 Released 2/10/70)

BACKGROUND

The crashworthiness of an automobile structure greatly depends on the way the kinetic energy of the vehicle is dissipated during various types of collisions. This capacity of the structure to dissipate energy is directly related to its force-deflection characteristics. The optimum structural performance in terms of providing the maximum energy dissipation capacity, while remaining below a prescribed deceleration level and utilizing the minimum amount of collapse distance, is a constant force-deflection relationship. Because present automobile structures provide little structural resistance between the front bumper and engine and also since they tend to exhibit linear force-deflection responses for increasing loads during low velocity impacts,

changes in the structural response require some departures from present design practices. Consequently, the achievement of significant changes in the structural performance must necessarily involve a rather long range research effort.

The investigation recently completed is primarily an experimental attempt to demonstrate possible changes in structural performance by making modifications in production automobiles. Because of the high incidence of fatal accidents involving front and side collisions, all modifications in this effort were confined to frontal and side impact investigations. The deceleration requirements selected were a 30g rectangular waveform for frontal impacts and a 20g rectangular waveform for side impacts.

The front end structure of typical full size production vehicles has a distance of approximately four feet between the front bumper and the compartment fire wall. If the collapse is restricted to this region and the structure is modified to exhibit a 30g rectangular waveform, then the energy dissipation capacity of the system is sufficient to dissipate the energy associated with 60 MPH fixed object collisions, without seriously intruding into the passenger compartment. Since the engine, which is about two feet in length, behaves as a rigid mass during the collision, and available acceptable collapse distance with current designs is restricted to about two feet, corresponding to an energy dissipation capacity for 40 MPH impacts if suitable structural modifications are made. The effort considered the problem at two levels: (1) modifying the structure so that the energy dissipation is primarily contained in the region in front of the engine and between the engine and fire wall, and (2) displacing or removing the engine so that the entire four feet is available for collapse. In the latter, more long range approach, two concepts, displacing the engine under the compartment and a rear engine vehicle, were pursued.

Because less than one foot of useful collapse is available on the sides of the passenger compartment in existing vehicle configurations, side compartment modifications present an intricate design problem. Structural modifications in three vital areas must be considered, i.e., reinforcement of (1) the door panels, (2) the passenger compartment structure and (3) the frame structure beneath the compartment. In the side impact modification phase of the program, structural modifications were made in each of these areas.

Nineteen vehicle tests were conducted during the program; of these, five were "base line" tests on the standard vehicle, two were primarily developmental tests to provide specific engineering information and three tests were performed within each of the four concepts pursued.

The test results of each of the vehicle modification concepts are reported in detail in the first four reports. In the Summary Report, information is provided for the performances of the standard and modified vehicles. Pertinent information on the testing procedures and data reduction, common to all tests, is also provided. Various static and dynamic component tests were performed in support of the vehicle modifications, and these test results are summarized.

During the program, a limited amount of effort was devoted to three analytical investigations. Specifically, a lumped mass, nonlinear spring dynamic model, a two-dimensional elasto-plastic frame computer program, and an analysis of side collisions were developed. The results of the analytical studies are presented in the fifth report.

MAJOR RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Results

- The major result of this study is the clear demonstration that a significant improvement in the capability of the structure to dissipate energy in a controlled manner in front and side collisions is possible. All of the concepts, the three related to front collisions as well as the one concerned with side impacts, show that for a given impact velocity a decrease in the vehicle collapse distance can be produced without significantly increasing the peak values for the compartment deceleration.

- Front collision concepts having both short and long range objectives were considered. That is, the forward structure modification concept demonstrated structural changes that could be readily incorporated into existing or conventional vehicle designs, while the engine deflection and rear engine concepts necessarily require extensive changes and some departures from conventional design practices. However, these latter two concepts provide an indication of the optimum performance in terms of the maximum energy capacity for the total collapse distance available.

- The program recognized that significant changes in the vehicle collapse performance would undoubtedly be a long range effort. Initially, the first two feet of the vehicle may be used as the primary energy dissipation region. Compartment integrity could be maintained in collisions with fixed, narrow objects (concentrated loadings) up to speeds of 40 MPH. The performance could be progressively improved by requiring more energy dissipation, with the same degree of compartment intrusion, until speeds of 60 MPH were reached. This would appear to be the maximum potential for current full size automobiles without going to velocity sensitive energy absorbers. Impacts at higher velocities would require either that more distance be made available in front of the passenger compartment for controlled collapse and/or that the potential benefits of velocity sensitive energy absorbers be exploited.

- Further research must be undertaken before it is advisable to issue a performance standard requiring that vehicle frontal structures exhibit passenger compartment decelerations that have high rates of onset and uniform levels, such as those demonstrated in the forward structure modification concept phase. These investigations should determine the effects such structures would have in car-to-car collisions. There are actually two basic problems involved in the car-to-car investigations:

  (1) impacts into unmodified or production vehicles

  (2) impacts into modified vehicles.

  If the front ends of the modified vehicles are designed so that the loads are properly distributed, it is considered probable that the results of striking a production vehicle with such a modified front end will be no worse than those presently encountered on the highways. The situation of a modified vehicle striking a modified vehicle will permit the possibility of considerable improvement in performance, because the compartment of the modified vehicles can be changed to be compatible with the impacting front end structures.

- Although the modifications for the side impacts were tested only in collisions with a fixed object, i.e., a lateral impact into a pole, the results of these studies could readily be extended to provide improvements for car-to-car collisions. The investigation should be extended to provide refinements in the structure so that the collapse characteristics of the compartment are compatible with those of the modified front end structures. However, based on the results of this investigation, it is clear that a significant increase in side impact protection will require extensive structure modification of present automobiles.

- The results of the engine deflection and rear engine vehicle tests strongly suggest that developing structures for 60 MPH impacts with fixed objects, where little intrusion into the compartment occurs, is a feasible objective. However, neither concept has yet been tested at this impact velocity. Further refinements should be pursued with each concept, and the resulting configurations should be tested under these more severe 60 MPH conditions.

- Another area that requires attention prior to issuing a performance standard is that of establishing means for measuring and conditioning the deceleration response. The measurement of vehicle deceleration depends on the location of the sensor(s) and the signal conditioning. Relevant data was obtained in the D-3 (47 MPH impact velocity) rear engine vehicle, where additional accelerometers were placed in the compartment at the in-board seat belt anchor points (norman installation in this program) and near the sides of the floor at the midpoints of the rear doors. Frame accelerometers were mounted on the frame torque-box region just in front of the rear wheels. Time histories of the outputs from these sensors are presented.

- The deceleration response for the sensor located at the seat belt anchor points were filtered with 50 Hz cutoff, 100 Hz roll-off and 25 Hz cutoff, 50 Hz roll-off frequency filters. The effects that the higher content have on the overall characteristics of the trace became evident. The higher frequency content can be misleading is such data were used to establish the peak deceleration values. It is quite probable that only the lower frequency content is meaningful in terms of the occupant response.

- Deceleration responses for the frame accelerometers are also given, and shows similar responses for the passenger compartment

sensors (all filtered with 25 Hz cutoff, 50 Hz roll-off filters). There are significant differences between the frame and body measurements; however, the sensors on the frame and body, respectively, exhibit the same general trends. Even though these trends are evident, at any given time the measured decelerations may vary by as much as 10g's.

- Assuming that the problems, particularly those relating to car-to-car impacts and data processing procedures, are adequately explored, then a performance standard should be issued. It is recommended that such a standard *not* require a square waveform per se, but rather that a given quantity of kinetic energy be dissipated in a specified collapse distance (which limits compartment intrusion) without exceeding a specified peak deceleration. The performance standard could readily be upgraded as progress is made in the development of crashworthy automotive structures. The same procedure, with different limiting conditions, could be used for both front and side impact performance.

- In frontal collisions at 40 MPH, the standard might specify that the maximum *filtered* deceleration should not exceed 40g's and that the compartment intrusion should not exceed a specified limit. For example, assume that a vehicle deformation (collapse) of two feet may occur and produce only negligible passenger compartment intrusion. Then this condition could be satisfied by a number of waveforms. The square waveform exhibiting the lowest peak deceleration and still satisfying the requirement is the 20g curve, while that having the highest peak deceleration is the 40g curve, where only 1.3ft of deformation occurs.

  On the other hand, the typical performance of most automobiles would be expected to depart somewhat from a square waveform and fall somewhere between these limits.

- Another area that must be considered in the specification of a performance standard is that of passenger compartment integrity being maintained during the compliance test. Since this problem is related to the interior compartment needs, it was not considered part of this program. The specification of minimum compartment dimensions should be based on the occupant behavior during the collision. Such specifications, resulting from interior studies, would automatically limit the amount of compartment intrusion that could be accepted.

- Suitable test conditions for compliance testing have not been extensively considered in this investigation. Rather, since only limited testing was possible within the scope of the program, test conditions were explored to determine the more severe test configurations. However, it is apparent from these results that compliance tests for measuring both frontal and side performances should probably specify impact into a narrow object, where the concentrated loads which are imposed on the structure generally increase intrusion severity.

- Manufacturing costs are, of course, important when considering changes in the structural performance of automobiles. However, throughout this study prime consideration has been devoted to the development and demonstration of concepts, and secondary emphasis was placed on the cost implications. The premise was that the possible safety benefits that result from these concepts should be first explored and then the production costs of these features be extensively investigated. Consequently, structural steels, where the member sizes are somewhat larger than automotive gauge, where used in the development of the modifications. Furthermore, continuous welding was employed at all joints. As a result, the structures developed in this study probably bear only slight resemblance (except for the basic collapse mechanism) to those that would eventually be designed for high volume production. Thus, production costs can be precisely estimated only after suitable manufacturing designs are available.

Conclusions

Conclusions are grouped according to the class of vehicles for which each specifically applies.

- Standard Vehicle

  - The structural response for frontal impacts into a flat barrier is very dependent upon the direction of impact.

  - For frontal impacts into an object that produces a concentrated loading, the initial slope of the deceleration displacement response is approximately 5g's/ft. This approximation is valid for the first two feet of collapse.

- The present structure permits excessive passenger compartment intrusion in relatively low velocity (20 MPH) side impacts into a rigid pole.

- Engine Deflection Concept

  - The feasibility of displacing the engine downward and/or lifting the passenger compartment during frontal collisions has been demonstrated. Both compression strut and sliding ramp principles were used to obtain the desirable separation of the engine and the passenger compartment.

  - Designing a front engine automotive structure with the capacity of dissipating the kinetic energy associated with 60 MPH impacts into fixed objects without seriously intruding into the passenger compartment is a reasonable objective. A modified automobile structure using the engine deflection concept has been tested in a 48 MPH collision with a fixed pole utilizing only three-fourths of the available frontal collapse distance.

  - As a minimum, two discrete masses are required to analytically model the behavior of front engine vehicles in the higher velocity impact range.

- Forward Structure Modification Concept

  - Deceleration responses of the passenger compartment, more uniform than those of current production automobiles, can be obtained for both head-on and oblique frontal collisions. The responses of all three modified vehicles, when compared to those of the standard vehicle, show a much shorter rise time in the deceleration waveform, while the peak values for deceleration do not vary significantly from those of the standard vehicle.

  - Stronger bumpers and properly designed bumper supports are required to distribute the impact loads resulting from head-on and oblique collisions with narrow objects.

  - The feasibility of design and development of automobile structures having a predetermined collapse mode, where local failure is primarily dependent on the bending moment distribution, has been established.

  - Plastic hinges that result from bending moments provide a reasonable way to dissipate kinetic energy during collisions. However, the tested experimental designs did not fully exploit the energy dissipation potential of the plastic hinge concept. If minor changes in the designs were made, more of the impact load could be transferred to the side of the vehicle opposite impact during oblique collisions.

- Rear Engine Concept

  - Inertial loads imposed on the structure behind the passenger compartment, as a result of a rear engine location, are not a serious impediment to the rear engine vehicle structural performance in frontal collisions.

  - A structural design of a rear engine automobile demonstrating a reasonably uniform deceleration of approximately 30g's has been shown to be feasible. This structural design has a collapse mode which confines a major portion of the energy dissipation to the regions between the front wheels and underneath the compartment.

  - Further refinement of the structure to obtain the collapse distance required for dissipating the energy of 60 MPH collisions at a uniform deceleration level without seriously deforming the passenger compartment appears to be a feasible objective.

  - The rear engine concept facilitates the use of members underneath the compartment as energy dissipation elements in front, side and rear end collisions.

  - Placing the engine in the rear rather than the front of the vehicle appears to result in more vehicle pitching and yawing in frontal collisions, but it is not apparent that these motions produce a more hazardous condition for the vehicle occupants.

- Side Modification Concepts

  - Two modified vehicle concepts have been designed and tested. These concepts, which involve structural changes, demonstrated discernible improvement over the base line vehicle structural performance. Specifically, these concepts were (1) a

modified door structure and (2) a modified vehicle frame. Details of the features and test results are presented in the appropriate sections of this report.

- For the limited space available in side impacts, it is essential that high loads be developed as early as possible. This can be accomplished either by having substantial structural members at the periphery of the vehicle, or by methods of directing load to the heavier frame members.

- For moderate weight increases (approximately 20 pounds per door), intrusion resistance can be improved somewhat in side impacts at a door opening without significantly higher peak deceleration by the addition of door beams and related structure. However, more significant improvement in occupant protection in side impacts will require extensive structural modification of present automobiles, particularly of the frame structure, in conjunction with an effective restraint system.

- For lateral impacts, it is not possible to completely characterize structural performance by a single acceleration time history. The above statement refers to the problem of inferring loads from acceleration data and is based on the results of comparisons of data from different accelerometer locations with the instrumented pole load data.

Recommendations

Recommendations are grouped according to the vehicle modification concept for which each specifically applies.

- Engine Deflection Concept

  - The overall concept should be further refined with the objective of testing the system in a 60 MPH collision with a fixed object. Assuming that a uniform compartment deceleration in the 30 to 40g range is acceptable from an injury threshold standpoint, the maximum energy dissipation capacity of this system is sufficient for 60 MPH impact conditions. The present effort strongly suggests that compartment integrity can be maintained in this environment and that the full potential of the system should be determined.

  - The relationship between engine location and the feasibility of engine deflection should be investigated. In the current study, the position of the engine was left unchanged, i.e., near the compartment fire wall. It is likely that placing the engine closer to the front of the vehicle would be beneficial to the separation process.

  - The possibility of changing the engine geometry should be considered in future refinements. In the present study, engine deflection was demonstrated with the largest engine available for the vehicle model. In future modifications, the possible benefits of altering the engine geometry consistent with normal engine operational requirements should be investigated.

  - The effect of compartment lift on the occupant kinematics should be explored. When the compartment is lifted during a collision, the occupant kinematics, relative to the compartment interior, are probably different from those normally occurring in front end collisions. Such compartment lift may significantly influence the way a passive restraint system, such as an air bag, should be installed.

  - Because of the initial experimental success with this concept and the high potential this system has as a safety feature, future experimental effort should be augmented by suitable analytical studies. Some of the problems associated with future design refinements, such as engine location, engine geometry, the collapsing structural mechanism desirable force-deflection characteristics, etc., should be investigated with simplified analytical models. The results of these studies should be used as a guide in selecting the parameters for the vehicle modifications.

- Forward Structure Modification Concept

  - Another vehicle incorporating the design changes resulting from the analysis of the Mod. 2A(2) test results should be built and tested obliquely into a rigid pole.

The objective of the test would be to demonstrate the total capability of the system for transferring the impact loads during oblique collisions.

- The implications of a generally constant deceleration response should be tested in car-to-car collisions. If the front ends of the modified vehicles are designed so that the loads are properly distributed, it is considered probable that the results of striking a production vehicle with such a modified front end will be no worse than those presently encountered on the highways. The situation of a modified vehicle striking a modified vehicle will permit the possibility of considerable improvement in performance, because the compartments of the modified vehicles can be changed to be compatible with the impacting front end structures.

- Rear Engine Concept

  - The full energy dissipation potential of a rear engine system should be demonstrated by making modifications in the design and testing the resulting configuration in a 60 MPH barrier or pole collision. It appears that with some rather straightforward modifications the design would permit the dissipation of the kinetic energy associated with 60 MPH collisions with little compartment deformation.

  - The rear engine vehicle concept would be tested in other collision configurations. A side collision into a pole is necessary in order to optimize the structural coupling between the front and side loading possibilities. The effects that pitching and yawing tendencies have during car-to-car collisions should also be investigated.

  - Instrumented dummies should be employed in future tests to determine the effects of the vehicle pitching and yawing on the occupant. It is considered to be unlikely that the occupant kinematics relative to the compartment interior will be substantially altered as a result of these motions.

  - A plastic frame structural analysis of the rear engine concept frame should be performed. Since the collapsing structure in the rear engine vehicle concept is primarily restricted to the two-dimensional frame, this system would seem to be a likely candidate for a rather complete plastic structural analysis. If such a computer program were developed, the structural mechanism could be subjected to various loading conditions in an effort to optimize the design parameters.

- Side Modification Concepts.

  - Additional side modifications, aimed at more fully achieving the goals of this research, should be developed and tested. A combination of the frame modification and the door modification already tested is suggested. Also, a vehicle that uses the roof structure more effectively than present vehicles should be tested.

  - Side impact tests of structurally modified vehicles at an impact speed greater than 20 MPH are warranted. Test results indicate that higher speed tests would demonstrate more dramatic improvement in structural performance in side impacts with fixed objects when compared with unmodified vehicle performance.

  - Close control of impact velocity and impact points is required in lateral collisions. Because of the low target velocity (20 MPH), small differences in impact velocities between vehicles can result in sizable differences in initial kinetic energy. Such speed errors may mask actual differences between vehicles or create apparent differences in performance that do not actually exist.

  - Placing accelerometers in very flexible locations, such as areas of the floorplan, should be avoided. Due to the flexibility of the vehicle, many accelerometers at rigid locations are desirable for performance evaluation. The 25 Hz low pass filter appears to be the best for inferring loads, comparing peaks and for other indices of behavior. Studies directed toward the validation and interpretation of data gathering and processing methods should be an integral part of any future test program.

General

The following recommendations pertain to the overall program, rather than to a specific modification.

- Although minimum weight of the modified vehicles was given consideration, the exploratory nature of the program precluded full investigation of all techniques that could demonstrate weight savings. Some of these techniques are:

  - hybrid design – different strength steels for different members, for example, A514 for the front bumper and A36 for other members that showed less distortion in tests;

  - tapered members – a commonly used method in plastic design;

  - improved utilization of existing sheet metal – hood, etc. – to absorb energy.

  Tests of modified vehicles incorporating some of the above weight saving concepts should be carried out.

- Other vehicle concepts that might enhance the compartment behavior during collisions should be explored. The development of such concepts should consider different structures and/or systems. For example, hydraulic systems are velocity sensitive and might produce certain advantages over velocity insensitive structures. Likewise, it may be possible to develop a structure that provides for vehicle redirection in certain types of collisions.

- The feasibility of manufacturing the more promising structural concepts should be explored. In the present study, attention was focused on the development of concepts; however, production costs can be accurately determined only after the feasibility of mass producting a structure exhibiting these characteristics has been established.

- Analytical techniques should be used to extrapolate test data beyond the conditions of the specific tests conducted. The crash tests are inherently destructive tests. To investigate different impact velocities, impact directions and types of impacted objects by experimental methods alone would be prohibitively costly. Neilson, et al (Road Research Laboratory, Report RL 132, 1968) demonstrates an analytical approach wherein experimental data are used to develop a model which is then used to predict behavior beyond the conditions of the original experiment. The analytical models developed in this program, could also be used in the above context.

The opinions, findings, and conclusions expressed in this summary are those of the contractor and not necessarily those of NHTSA.

Availability of documents: NTIS (Formerly Clearinghouse – CFSTI), U. S. Department of Commerce, Springfield, Va. 22151.

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